Page 2, please replace the paragraph beginning at line 3 with the following:

A2 As a device for heating the sensor tube of the above-mentioned thermal type flow rate sensor, a heating resistor in the form of a wire is wound in a coil around an outer wall surface of the sensor tube so as to provide a resistance of about 100 to 300 Ω, and a current is supplied to the heating resistor for heating. The length of the coil is about several mm, and the sensor tube has an inner diameter of about 0.3 mm and an outer diameter of about 0.4 mm. About 100 mW of power is supplied to the heating resistor, so as to heat the heating resistor to about 80°C. A fluid is flowed in the sensor tube in this state, and variation of a resistance of the heating resistor is detected during flow of the fluid (reference is made to, for example, U.S. Patent No. 3,938,384).

Pages 3-4, please replace the paragraph beginning on page 3, line 25, with the following:

A3 According to the present invention, there is provided a flow rate sensor comprising: a pair of heating resistors operable to heat a sensor tube; a temperature sensor operable to control respective temperatures of the heating resistors; and a case operable to hold the heating resistors and the temperature sensor.

Page 4, please replace the paragraph beginning at line 3 with the following:

A4 The flow rate sensor is adapted to detect a flow rate of a fluid flowing in the sensor tube, based on variations of voltages applied to the heating resistors, wherein the variations occur according to the flow rate of the fluid. The sensor further comprises a voltage applying device operable to arbitrarily set an increase in temperature of each of the heating resistors. The sensor tube has opposite ends thereof thermally connected to the case. The temperature sensor is positioned to be equidistant from the opposite ends of the sensor tube.

Page 5, please replace the paragraph beginning at line 7 with the following:

A5 Fig. 1 shows a relationship between the resistance of and the power supplied to a heating resistor for explaining the principle of a flow rate sensor of the present invention.

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Page 5, please replace the paragraph beginning at line 10 with the following:

A6

Fig. 2 is a plan view of the flow rate sensor according to a first embodiment of the present invention in which an upper case is removed.

Page 5, please replace the paragraph beginning at line 18 with the following:

A7

Fig. 5 is a plan view of the flow rate sensor according to a second embodiment of the present invention in which an upper case is removed.

Pages 5-6, please replace the paragraph beginning on page 5, line 27, with the following:

A8

Fig. 8 is a cross-sectional view of the sensor tube of Fig. 7 according to the second embodiment of the present invention taken along the line X-X.

Pages 6-7, please replace the paragraph beginning on page 6, line 21, with the following:

A9

Hereinbelow, a flow rate sensor of the present invention is described, referring to Figs. 1 to 12. In Figs. 1 through 12, the same parts or portions are designated by the same reference numerals and characters, and overlapping explanations thereof are omitted. First, the principle of the flow rate sensor of the present invention is explained. Generally, in thermal type flow rate sensors, when the power applied to the heating resistor is increased to thereby increase the heating temperature, the sensitivity of the sensor becomes high. Therefore, as a method for improving the sensitivity of the thermal type flow rate sensor, a method of increasing the voltage applied to the heating resistor is generally employed.

Page 7, please replace the paragraph beginning at line 6 with the following:

A10

However, the above-mentioned method cannot be applied to a fluid susceptible to heat. Therefore, the inventor of the present invention has investigated an output sensitivity of the thermal type flow rate sensor when the power applied to the heating resistor is maintained at a predetermined level. As a result, a characteristic curve b such as indicated in a graph shown in Fig. 1 has been obtained. That is, it has been found that when a resistance R of the heating resistor increases, a

A10 cont.

detection sensitivity (relative sensitivity) of the sensor increases in proportion to the square of the resistance R of the heating resistor.

Pages 7-8, please replace the paragraph beginning on page 7, line 17, with the following:

A11

On the other hand, when the resistance R of the heating resistor is increased while maintaining a voltage V applied to the heating resistor at a predetermined level, a power P supplied to the heating resistor decreases as indicated by curve a shown in the graph of Fig. 1. In view of this fact and the above-mentioned finding that the detection sensitivity becomes high as the resistance of the heating resistor becomes high, the inventor of the present invention has found that when a measurement range of flow rate is appropriately selected, it is possible to obtain a flow rate sensor having a desired sensitivity. Specifically, the inventor of the present invention has found from results of experiments that sufficient sensitivity can be obtained by using the heating resistor having a resistance of about 600 Ω, even when the power applied to the heating resistor is as low as about 25 mW.

Page 8, please replace the paragraph beginning at line 14 with the following:

A12

Figs. 2 and 3 show an arrangement of a flow rate sensor according to a first embodiment of the present invention. A rectangular upper case 1A and a rectangular lower case 1B are fixedly connected to each other via screws, to thereby obtain a case 1. Each of the upper case 1A and the lower case 1B includes: a U-shaped groove 2 which provides a space for containing a central portion of a U-shaped sensor tube 32; bore portions 4 for containing circular flanges 3 to be fitted onto opposite end portions of the sensor tube 32; and connecting grooves 5 for connecting the groove 2 and the bore portions 4. The sensor tube 32 is made of stainless steel (JIS SUS 316) and has an outer diameter of 1.6 mm and an inner diameter of 0.8 mm.

Pages 12-13, please replace the paragraph beginning on page 12, line 3 with the following:

A13

As each of the heating resistors R_1 and R_2, use is made of a resistor having a temperature coefficient of about 3,800 ppm which is the same as the temperature coefficient of the temperature

A13 cont.

measurement matching resistors R_5 and R_6. As mentioned above, the temperatures of the heating resistors R_1 and R_2 are 3 °C higher than those of the temperature measurement matching resistors R_5 and R_6, that is, 23 °C. Therefore, as each of the heating resistors R_3 and R_4, a resistor having a resistance of 1,087 Ω is used. In this arrangement, a current is supplied to the bridge circuits until respective temperatures of the heating resistors R_1 and R_2 become 23 °C and the value of a resistance of each of the heating resistors R_1 and R_2 becomes 1,087 Ω, to thereby conduct heating. In this instance, the current is also supplied to each of the temperature measurement matching resistors R_5 and R_6. However, an increase in temperature of the temperature measurement matching resistors R_5 and R_6 can be ignored, because the lower case 1B is made of aluminum having a sufficiently large heat capacity as compared to the sensor tube 32 and the temperature measurement matching resistors R_5 and R_6 are adhered to the lower case 1B by means of an adhesive material. Heating of the temperature measurement matching resistors R_5 and R_6 can be easily prevented by setting the value of resistance of each of the temperature measurement matching resistors R_5 and R_6 and the heating resistors R_7 and R_8 to a high level. In the flow rate sensor in this embodiment, when ETOH (ethyl alcohol) was used as the flow fluid in the sensor tube 32, satisfactory output linearity could be obtained in a measurement range of flow rate of from 0 cc/min. to 0.1 cc/min. Further, because the temperature of the sensor tube 32 was maintained at a low level, stable measurement could be conducted without occurrence of a problem such as formation of air bubbles in the ETOH, which is encountered in conventional techniques. In the present invention, the problem of formation of air bubbles can be avoided in most fluids by limiting an increase in temperature of the heating resistors for heating the sensor tube 32 to 5 °C or less. According to the present invention, it has become possible to conduct appropriate measurement of a flow rate even when an increase in temperature of the heating resistors is extremely small, i.e., 5 °C or less. Thus, in the first embodiment of the present invention (as well as other embodiments of the present invention), use is made of a voltage applying device operable to apply voltages to the heating resistors so that an increase in temperature of the sensor tube due to the effect of the heating resistors is several degrees Celsius.

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Pages 14-15, please replace the paragraph beginning on page 14, line 17, with the following:

In the flow rate sensor arranged as mentioned above, in which the plurality of inner tubes 53 are provided within the sensor tube 52, a laminar flow of fluid was obtained and as a result of this, an improvement of output characteristics was observed. Fig. 9 shows the improvement of output characteristics of the flow rate sensor in this embodiment. In Fig. 9, a curve j indicates output characteristics of the sensor utilizing the sensor tube 52 which has the inner tubes 53 provided therein. A curve k indicates output characteristics of the sensor utilizing the sensor tube having no inner tubes 53. From Fig. 9, it is understood that with respect to the sensor utilizing the sensor tube 52 (having the inner tubes 53 provided therein), a flow rate range in which a linear output is obtained is about three times wider than that of the sensor utilizing the sensor tube having no inner tubes 53.

A14

Page 15, please replace the paragraph beginning at line 15 with the following:

Each of the upper and lower cases of the tube guide 60 includes: a U-shaped groove 61 for containing the U-shaped sensor tube 52, such that the U-shaped sensor tube 52 is in contact with the tube guide 60; recesses 62 for containing the circular flanges 3 to be fitted onto the opposite end portions of the sensor tube 52; and a threaded bore 63. The threaded bore 63 is used for connecting the upper case and the lower case via screws, after the upper and lower cases are fixed to each other by using an adhesive material so as to cover the sensor tube 52. Each of the upper and lower cases includes a slot 64 conforming to the shape of the sensor tube 52.

A15

Pages 15-16, please replace the paragraph beginning on page 15, line 27, with the following:

The tube guide 60 is provided from the viewpoint of rapid transition to heat balance in the sensor tube 52. That is, although the sensor tube 52 is made of stainless steel (JIS SUS 316) to provide high corrosion resistance, corrosion-resistant alloys such as stainless steel have poor heat conductivity. In addition, the sensor tube 52 has poor output response time due to its relatively large diameter. Therefore, as mentioned above, the sensor tube 52 is entirely covered with the tube guide 60 made of a material having high heat conductivity, such as aluminum. By this arrangement, the

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A16 Cont

occurrence of heat balance in the sensor tube 52 can be accelerated, leading to a quick output response time.

Page 16, please replace the paragraph beginning at line 12 with the following:

A17

The tube guide 60 is contained in the upper case and the lower case 11B [shown in Figs. 11a and 11b] of the rectangular case. The case is obtained by fixedly connecting the upper case and the lower case 11B via screws. Each of the upper case and the lower case 11B includes a recess 55 confirming to the contour of the tube guide 60, for accommodating the tube guide 60.

Pages 16-17, please replace the paragraph beginning on page 16, line 19, with the following:

A18

In this embodiment, four heating resistors 70-1 to 70-4 (Fig. 5) are attached to the tube guide 60. Each of the heating resistors 70-1 to 70-4 comprises a platinum chip resistor including a ceramic substrate and a platinum resistor deposited on the substrate by vapor deposition. The value of a resistance of each of the heating resistors 70-1 to 70-4 is 1 k Ω. The heating resistors 70-1 and 70-2 are connected in parallel so as to correspond to the heating resistor 35A in Fig. 4, and the heating resistors 70-3 and 70-4 are connected in parallel so as to correspond to the heating resistor 35B in Fig. 4.

Page 17, please replace the paragraph beginning at line 2 with the following:

A19

Thus, two resistors each having a resistance of 1kΩ are connected in parallel and are used as a heating resistor having a resistance of 500 Ω. By this arrangement, sufficient sensitivity of the sensor can be obtained by supplying less current, that is, by generating less heat, as compared to the conventional wound type heating resistor having a resistance of about 100 Ω to 300 Ω.

Pages 17-18, please replace the paragraph beginning on page 17, line 17 with the following:

A20

When the fluid flows in the sensor tube 52, due to the occurrence of transmission of heat through the fluid, the voltages applied to maintain the temperature of the heating resistors 70-1 to 70-4 on the tube guide 60 at a predetermined level vary. By detecting the variations of the applied

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voltages, a mass flow rate of the fluid can be detected. In the embodiment shown in Fig. 5, satisfactory output linearity could be obtained in the flow rate range of 0 to 6 cc/min. The tube guide 60 is out of a cartridge type. Therefore, to conduct measurement over different flow rate ranges, the same sensor can be used simply by replacing the tube guide 60 with another tube guide suitable for a desired flow rate range. Thus, the sensor can be applied to measurement over a wide range of flow rate ranges.

A20 cont

Page 18, please replace the paragraph beginning at line 3 with the following:

Thus, in the second embodiment, measurement can be conducted over a wide range of flow rate via a small flow rate sensor without the need to use the bypass portion. Further, because a material having high heat conductivity is used for the tube guide 60, a response time for output can be reduced, leading to a quick response. Because the tube guide 60 is used, it is possible to replace a conventional cumbersome operation for winding the heating resistor around the sensor tube by adhering the chip resistor on the tube guide. This markedly improves manufacturing efficiency with respect to the sensor. With regard to the chip resistors used as the heating resistors on the tube guide 60, a chip resistor which produces only extremely minor measurement errors at an arbitrary value of resistance can be easily obtained. Therefore, the sensor including detection circuits can be designed with a high degree of freedom. Further, the heating temperature for the sensor tube 52 is controlled so that it is merely 2°C higher than the reference temperature of the case 1, so that the sensor tube can be applied to the fluid susceptible to heat. Needless to say, providing narrow tubes in the sensor tube and using the metallic thin-film chip resistors as the heating resistor in this embodiment can be applied to other embodiments of the present invention.

A21

Pages 18-19, please replace the paragraph beginning on page 18, line 27, with the following:

Next, referring to Fig. 12, a flow rate sensor according to a third embodiment of the present invention is explained. In this embodiment, silver plating 33 is formed on a surface of the sensor tube 32 so as to improve heat transmission on the sensor tube 32. The sensor tube 32 having the silver plating 33 formed thereon is applied to the flow rate sensor in the first embodiment shown in

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A22 cont

Figs. 2 and 3. Therefore, a wound type resistor is applied to the sensor tube 32. The value of resistance of this wound type resistor is 1 kΩ which is higher than that of the conventional wound type resistor. An amount of change in the value of resistance of the resistor due to a temperature change is increased so as to operate the sensor at a low heating temperature.

Page 19, please replace the paragraph beginning at line 13 with the following:

A23

Because the silver plating having high heat conductivity is formed on the surface of the sensor tube 32, the occurrence of heat balance on the sensor tube 32 is accelerated, leading to a quick response time. In the third embodiment, the sensor tube 32 is a narrow tube having an inner diameter of 0.8 mm. Therefore, it is unnecessary to provide narrower tubes in the sensor tube 32.

Pages 19-20, please replace the paragraph beginning on page 19, line 20, with the following:

A24

As has been described above, the flow rate sensor of the present invention comprises a pair of heating resistors operable to heat a sensor tube, a temperature sensor operable to control respective temperatures of the heating resistors and a case operable to hold the heating resistors and the temperature sensor, wherein the sensor is adapted to detect a flow rate of a fluid flowing in the sensor tube based on variations of voltages applied to the heating resistors, wherein the variations occur according to the flow rate of the fluid, and voltage applying device operable to arbitrarily set an increase in temperature of each of the heating resistors. Therefore, according to the present invention, a flow rate sensor which has high sensitivity and which produces only extremely minor measurement errors under the influence of heat can be obtained by appropriately selecting the values of resistance of the heating resistors so that an increase in temperature of the sensor tube due to the effect of the heating resistors in several degrees Celsius.

IN THE CLAIMS:

Please amend the claims as follows:

Kindly cancel claims 1-15 without prejudice or disclaimer of the subject matter thereof.

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